Whitetopping Performance in Illinois

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16. Abstract

Between 1998 and 2004, nine experimental whitetopping projects were constructed in Illinois and their field performance was evaluated. Five of these projects involved the rehabilitation of highway intersections and the remaining four were a rehabilitation of mainline pavements. The projects were constructed on U.S. Highways, Illinois State Routes, and County Highways. These projects included the use of ultrathin whitetopping, thin whitetopping, and bonded concrete overlays of brick pavers and concrete.

This report explores the performance for all nine projects through the end of 2004. A summary of the construction methods has been included for each project as a quick reference. Detailed traffic volumes, visual distress surveys, and soundings of the whitetopping projects were used as performance measures. These values and tests were collected or performed on an annual basis where applicable.

The performance of the mainline pavement rehabilitations has been excellent to date except for a few minor distresses in one of the projects. The performance of the whitetopping sections of the intersection rehabilitations has also been excellent. The performance of the bonded concrete sections at the intersection rehabilitations has been satisfactory.

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Final Report

WHITETOPPING PERFORMANCE IN ILLINOIS

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ABSTRACT

Between 1998 and 2004, nine experimental whitetopping projects were constructed in Illinois and their field performance was evaluated. Five of these projects involved the rehabilitation of highway intersections and the remaining four were a rehabilitation of mainline pavements. The projects were constructed on U.S. Highways, Illinois State Routes, and County Highways. These projects included the use of ultrathin whitetopping, thin whitetopping, and bonded concrete overlays of brick pavers and concrete.

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INTRODUCTION

Highway intersections present numerous obstacles for highway designers, builders, and maintainers to overcome. Perhaps the most challenging obstacle is the repair of an intersection with a significant amount of daily traffic which may or may not include heavy commercial vehicles. The stopping, starting, and turning actions of these vehicles induce a considerable amount of surficial distress to the pavement within the intersection. The surficial distress is especially apparent if the intersection has a hot mix asphalt (HMA) pavement surface. This surficial distress may include rutting, shoving, raveling, or an array of cracking patterns.

In the last 50 years, the use of “whitetopping” for intersection repair has been experimented with by several state and local agencies across the country. Whitetopping is simply defined as a portland cement concrete overlay or inlay of an intersection or highway with a bituminous surface material. In Illinois, whitetopping may be divided into three separate groups depending on the thickness of the overlay and the application.

“Ultrathin” whitetopping is defined as a concrete overlay or inlay with a thickness less than 4.0 inches. This definition only applies to concrete overlays and inlays that are placed on HMA surfaces. A bond between the concrete overlay or inlay and the underlying HMA is assumed with this repair method. Ultrathin whitetopping is typically used for intersection repair and may occasionally be used for surface repair of a very low volume roadway.

A “conventional” or “thin” whitetopping is defined as a concrete overlay or inlay with a thickness between 4.0 inches and 8.0 inches. This definition also only applies to concrete overlays and inlays that are placed on HMA surfaces. A bond between the concrete overlay or inlay and the underlying HMA may or may not be designed for with this repair method. Thin whitetopping is typically used for the surface repair of highways but may occasionally be used for intersection repair.

An “unbonded concrete overlay” may be defined as a concrete overlay with a thickness greater than 8.0 inches. This type of concrete overlay is a unique version of whitetopping that includes the use of steel reinforcement and is used almost exclusively for the surface repair of highways. Once again, this definition only applies to a concrete overlay that is placed on a HMA surface. There is no assumption of bond between the concrete overlay and the underlying HMA with this repair method.

A “bonded concrete overlay or inlay” may be defined as a concrete overlay or inlay of any thickness that is placed directly on an existing concrete surface. This rehabilitation method is not considered whitetopping. A bond between the concrete overlay and the existing concrete surface is always assumed with this repair method. Bonded concrete overlays may be used for the repair of intersections or highways depending on the thickness of the overlay or inlay.

Illinois first researched the experimental use of whitetopping in 1998 with the construction of three intersection projects. Since those first three intersections, the process has been used on several more state maintained intersections and highways as well as numerous local agency roadways and privately owned facilities.

This report covers the performance of seven projects which were initially selected for research review. Also included are the construction and performance details for two additional projects that were included later with this research effort. Illinois Physical Research Report No. 144 [1] documents the construction and initial performance for the seven projects initially selected for this research effort.

The nine projects selected include five intersection projects and four mainline pavement projects. The five intersection projects include four with a combination of ultrathin whitetopping and bonded concrete inlays and one that is strictly a bonded concrete inlay. The four mainline projects are all considered thin whitetopping. Also, the five intersections are all on state-maintained facilities. One of the mainline projects is on a state-maintained facility, while the remaining three are on county-maintained facilities.

MIDWEST PERSPECTIVE

The use of concrete overlays or “whitetopping” is not a new concept to highway construction and rehabilitation. In fact, concrete overlays have been used since the middle 1900’s across the country. Reports from Iowa indicate that concrete overlays have been used on their local road highway system since as early as 1960 [2]. The big push for the use of whitetopping did not occur until the early 1990’s with a small experimental project at a landfill in Louisville, Kentucky. This project provided many research-related opportunities and answers. Based on this project, many more state and local government entities began experimentation with whitetopping. Following is a brief summary of the whitetopping experience for some of the Midwestern states in the last 15 years.

Kentucky [3]

In September, 1991 construction took place on an experimental ultrathin whitetopping project at a landfill in Louisville, Kentucky. The landfill’s main access road offered an excellent opportunity to evaluate the performance of an ultrathin whitetopping. This access road is the access for all the loaded and unloaded trucks to the weigh scales and the landfill. In addition, the access road is straight and flat which eliminated possible ill effects from turning and acceleration / deceleration movements.

The existing HMA pavement displayed some rutting in the inbound travel lane and therefore, the entire surface of both lanes was milled to provide a uniform cross section. Two 275-foot test sections were constructed at the site. The first test section was 2.0 inches thick with polypropylene fibers and a 6.0-foot by 6.0-foot relief joint layout. The second section was 3.5 inches thick with polypropylene fibers and a 6.0-foot by 6.0-foot relief joint layout. The entire project was completed in one weekend in order to facilitate the continued operation of the landfill.

The experimental evaluation of the project was completed after the first year with nearly one million 18-kip equivalent single axle loads passing over the experimental sections. Some corner cracks were present in the panels, and a couple of transverse cracks were observed, but no concrete was removed nor were any repairs completed before the end of the evaluation.

Tennessee [4]

The Tennessee Department of Transportation began experimentation with whitetopping after the favorable results reported from the Louisville, Kentucky project. The emphasis in Tennessee was on developing a rehabilitation procedure for heavily trafficked intersections that were requiring repairs to the HMA surface on an annual or biennial basis.

Eight test sections were constructed across the state between 1992 and 1995. These test sections provided early lessons into potential causes for a whitetopping failure. The existing HMA surface should be milled and properly cleaned to ensure a good bond of the whitetopping to the HMA. Also, the amount of remaining HMA must be adequate and of a reasonably sound quality. The test sections also provided some experience with design features that were a key to the success to the projects. A joint spacing of 1.0-foot per inch of overlay thickness was effective. In addition, utilizing early entry techniques for the saw cutting reduced the amount of random cracking. Finally, high early strength concrete mixes with the addition of polypropylene fibers were used to improve strength, increase crack resistance, and allow traffic on the overlay in a short amount of time.

Based on the success of the early test sections, several more projects were let for bid in the cities of Nashville, Memphis, and Athens. These projects included the heavily trafficked bus lanes in downtown Nashville and four of the busiest intersections in Memphis. These projects provided strong evidence that whitetopping can be constructed in a short amount of time at busy intersections. Also, cost comparisons indicated that the whitetopping would be more cost effective than an HMA overlay, for the life of the overlay, if the whitetopping lasted at least eight years.

Minnesota [5]

In 1993, the Minnesota Department of Transportation constructed several test sections along TH30 in southern Minnesota. The goal of these test sections was to provide information and build confidence for future projects in Minnesota and beyond. The test sections included four whitetopping overlays, two HMA overlays, and a standard concrete overlay control section. Two thickness variations of 5.0 and 6.0 inches were used along with combinations of bonded and unbonded situations. All of the transverse joints were spaced at 12.0 feet and were skewed. One test section experimented with dowelled joints, while the remaining three test sections and one control section were not dowelled. One test section was placed on a milled surface, while the remaining three test sections and one control section were placed directly on the existing distressed HMA surface.

Results from the construction and performance evaluation of these test sections have indicated the following key points. Overlay paving of the existing distressed surface resulted in an average pavement thickness that was 0.5 inch greater than required. Overlay paving of the milled test section produced the lowest standard deviation from the required overlay thickness. Visual distress surveys indicated very little distress in the concrete overlay sections; however, there were numerous thermal cracks and there was some rutting present in the HMA overlay sections. These moderate severity cracks in the HMA sections were sealed and the surface was given a chip seal application in 1997 after only four years of service.

The whitetopping sections have shown no faulting after nine years of service and the load transfer efficiency is approximately 90 percent for all the test sections. The ride quality index for all of the whitetopping sections has remained relatively constant, while that of the HMA overlays has nearly doubled. The whitetopping placed on the milled surface was initially the smoothest of the concrete overlaid sections and it continued to be the smoothest section after nine years of service. Cost comparisons indicate that based on an equivalent uniform annual basis with maintenance, the whitetopping sections are equivalent to the HMA sections, and in some cases actually more economical.

Iowa [6]

The State of Iowa has experimented with the use of whitetopping since the 1960’s. The majority of this work has been done on low volume county roads. Following the success of the Louisville, Kentucky project, in 1994 the Iowa Department of Transportation decided to further evaluate whitetopping as part of its participation in Section 6005 of the

Intermodal Surface Transportation Efficiency Act (ISTEA). The selected project is located on Iowa Route 21 in Iowa County just south of Belle Plaine.

The project is divided into 65 different test sections with a multitude of test variables. Overlay thickness variations of 2.0, 4.0, 6.0, and 8.0 inches were used in combination with joint spacings of 2.0, 4.0, 6.0, 12.0, and 15.0 feet. Plain concrete mixtures as well as mixtures with monofilament and fibrillated polypropylene fibers were used in the test sections. Finally, three types of HMA pavement preparation techniques were used including patching only, patching and scarification, and cold-in-place recycling.

Results from this research effort indicated several combinations of variables that performed well and some that did not. The patching and scarification method of base preparation provided the best bond strength. Visual surveys indicated corner cracking and some mid-panel cracking of the 2.0- and 4.0-inch overlay thickness areas, but very limited cracking was noted in the 6.0- and 8.0-inch sections. The addition of fibers to the concrete mixture was beneficial for restraining crack width in the 2.0-inch overlay sections. A benefit from the addition of fibers in the 4.0-, 6.0-, and 8.0-inch sections was inconclusive. A joint spacing pattern of 4.0 by 4.0 feet or 6.0 by 6.0 feet in the 4.0-inch overlay section worked very well. A pattern of 4.0 by 4.0 feet in the 2.0-inch overlay section produced many corner cracks, and a pattern of 6.0 by 12.0 feet in the 6.0-inch overlay produced some mid-panel cracks.

Ohio [7]

The Ohio Ready Mixed Concrete Association experimented with three ultrathin whitetopping projects across the state of Ohio during the mid 1990’s. All three projects were located on county roads and were constructed with the same concrete mixture design as 2.0-inch overlays. Test sections were constructed with nylon, polypropylene, and steel fibers, as well as various joint spacing patterns.

Several conclusions were made from these three demonstration projects. A joint spacing layout of 12 to 18 inches per inch of overlay thickness is ideal for the control of random cracking. Also, an ultrathin whitetopping will not bridge any major defects in the existing HMA surface such as wide thermal cracks. There appears to be no performance difference in the three types of fibers added to the concrete mixture. Finally, a thickened edge should be used at edges of the whitetopping that do not butt up to existing concrete.

Kansas [8]

In 1995, Kansas placed an ultrathin whitetopping over a one-half mile stretch of an urban thoroughfare in the city of Leawood. This project involved milling 2.0 inches of the existing HMA surface and replacing it with 2.0 inches of concrete. Test sections were established to evaluate various panel sizes, normal versus fibrillated fiber reinforced concrete, and the use of joint sealants. Funding for the project was provided through Section 6005 of the ISTEA.

Corner cracks and some surface distress in an area of construction difficulty were noted one year after construction. A few panels were replaced due to subgrade problems. Corner cracks continue to be the major distress for this inlay project.

Kansas has also used whitetopping for intersection rehabilitations in Topeka and Lenexa. The repair of these intersections has proven to provide better service than HMA overlays which tend to rut and shove at these areas of starting and stopping traffic.

Missouri [9]

The Missouri Department of Transportation has experimented with whitetopping at three locations. The first project included an intersection and 0.8 mile of mainline pavement in Neosho. This project involved milling 2.0 to 4.0 inches of HMA and placing a 4.0-inch whitetopping with relief joints at 4.0 feet in the longitudinal and transverse directions. The second and third projects were both intersections in the cities of St. Joseph and Independence, respectively. The intersection project in St. Joseph included milling 3.0 inches of the existing HMA and replacing it with 3.0 inches of concrete and relief joints on 3.0-foot centers. The Independence project utilized a 4.0-inch concrete inlay for the intersection with relief joints on 4.0-foot centers.

Construction for all three of these projects involved the use of synthetic fibers in a high early strength concrete mixture, and the maturity concept for strength gain and approval to open the project to traffic. The maturity concept involves investigating the concrete mix design in the laboratory for strength gain based on the concrete mix temperature and time. Based on the results of this investigation, the concrete mix temperature and time can be analyzed for opening the project to traffic versus making concrete cylinders and beams for compression and flexural testing.

Early performance reviews indicate some corner and mid-panel cracking; however, much of the cracking can be correlated to underlying pavement distress or construction problems. Falling weight deflectometer analysis indicates that the overlay is performing as a composite pavement structure with modulus values equivalent to a structurally sound full-depth HMA pavement.

METHOD OF EVALUATION

The intent of this section is aimed at outlining the method of evaluation that was used for the projects detailed later in this report. Several factors should be considered when evaluating the performance and success or failure of a whitetopping project. These factors include traffic records, visual surveys, pavement sounding, maintenance repairs, and the lifespan of the project.

These factors have been included with the evaluation of the nine projects selected for this research. Traffic records, including heavy commercial vehicle counts, have been collected by the Illinois Department of Transportation (IDOT) on a biennial basis for all of the state maintained projects. These records have also been collected for the local agency projects, but on a less frequent basis. The data for missing years have been interpolated using the data that are available. The traffic volumes were also converted to 18,000 pound equivalent single axle loadings (ESALs) using the appropriate design equations from the IDOT Design Manual [10]. The ESAL values may be compared between projects and between whitetopping and other repair methods.

Visual surveys of the selected whitetopping projects were also completed on an annual basis. Surficial distress was denoted according to the Distress Identification Manual for the Long-Term Pavement Performance Project [11]. All patch locations and areas of routine maintenance were recorded in the visual surveys. In addition to the visual survey, a pavement sounding was done to locate areas where the whitetopping had debonded from the underlying pavement. Finally, the lifespan of each project should be recorded along with the condition of the overlay at the time of removal. This process was not completed for this report but should be included in future research on the use of whitetopping.

PROJECT PERFORMANCE

The performance for several whitetopping and bonded concrete inlay / overlay projects was evaluated as part of this research effort. Annual visual distress surveys were the primary means for determining performance. The amount of accumulated ESALs was also taken into account when measuring performance.

The visual distress surveys were used to record the number of panels within a project that were cracked or displayed some other type of distress such as debonding from the underlying pavement or spalling of the relief joints. The distress was recorded and assigned a severity level according to the Distress Identification Manual for the Long-Term Pavement Performance Project [11].

Traffic data were collected for each project in various years. Traffic data are collected on a biennial basis for state maintained routes and on a less frequent basis for county and local agency maintained routes. Data for non-collection years were interpolated between data for collection years. These data include a breakdown of passenger vehicles, single unit trucks, and multiple unit trucks. These numbers were used to calculate the amount of ESALs accumulated for each year and for the project to date.

More specific information on the evaluation of each project may be found below. Information includes a brief overview of the project’s construction, information on the accumulated traffic loadings, and information on the performance of the project to date.

DECATUR – INTERSECTION OF U.S. HIGHWAY 36 AND OAKLAND AVENUE

The intersection of U.S. Highway 36 and Oakland Avenue is located on the west side of the city of Decatur. This project was the first one built for the purpose of evaluating ultrathin whitetopping in Illinois. The rehabilitation included the two eastbound lanes of U.S. Highway 36 only. Construction was completed in the spring of 1998.

The existing pavement structure consisted of both concrete pavement and brick paver areas that were overlaid with HMA. The milling operation exposed the original concrete pavement; however, the brick pavers remained under several inches of HMA. Therefore, this project is considered to be a combination of an ultrathin whitetopping and a bonded concrete inlay. The western most third of the project is considered to be a 3.5-inch bonded concrete inlay, while the remainder of the project is considered to be a 3.5-inch ultrathin whitetopping inlay.

Relief joints were placed over cracks in the existing pavement and at the boundaries of the two patches placed in the original pavement. The remainder of the joints were laid out on an equidistant pattern between these initial joints. The resulting average panel dimensions for the project were 3.6 feet by 4.3 feet. There were no skewed transverse joints used on this project.

This intersection carries a significant amount of light vehicle traffic from commuters entering Decatur for work from outlying areas. There is also a small percentage (six to nine percent) of heavy commercial vehicle traffic that passes through this intersection. The values given below in Table 1 indicate the amount of traffic and accumulated ESALs that this project has carried to date. As can be seen in the table below, this project has carried a fairly constant amount of traffic each year during the evaluation period. To date, this project has seen roughly 1,000,000 ESALs.

Table 1

Traffic Volumes for U.S. Highway 36 and Oakland Avenue

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
1999	17,800	925	475	16,400	0.18	0.18
2000	17,150	675	325	16,150	0.13	0.31
2001	16,500	950	500	15,050	0.19	0.50
2002	17,000	875	450	15,675	0.17	0.67
2003	17,500	800	400	16,300	0.15	0.82
2004	18,000	900	500	16,600	0.18	1.00

*Highlighted cells are interpolated data points.

The performance of this project is mixed between the two types of rehabilitation present. This project serves as an excellent comparison between these two types of repair given that they are in the same location and receive the same traffic loadings. The values below in Table 2 indicate the number of panels that have a visible crack or distress for both sections.

Table 2

U.S. Highway 36 and Oakland Avenue Survey Results

Year of Survey	**1999**	**2000**	**2001**	**2002**	**2003**
3.5-Inch Inlay With 3.6- By 4.3-Foot (Avg.) Panels					
Number of Panels Over HMA	181	181	181	181	181
Number of Panels Cracked	4	14	21	26	34
Percentage Cracked	**2.2**	**7.7**	**11.6**	**14.4**	**18.8**
Number of Panels Over Concrete	99	99	99	99	99
Number of Panels Cracked	63	63	69	71	77
Percentage Cracked	**63.6**	**63.6**	**69.7**	**71.7**	**77.8**

Nearly 64 percent of the panels within the bonded inlay section cracked after only one year of service compared to only two percent in the whitetopping section. The number of cracked panels continued to increase for both sections throughout the five year evaluation period. The rate of increase for cracked panels between the two sections was nearly the same at roughly a 15 percent increase over five years. The majority of the cracks observed were low severity mid-panel cracks. Three of the panels in the whitetopping section and six of the panels in the bonded inlay section were considered to have medium severity cracks at the end of the evaluation.

The bond of the concrete inlay was tested with a sounding rod during the visual distress surveys. The results of this test are subjective as they are based on the opinion of the operator. Results were tabulated strictly as a quick and easy evaluation for the area of debonded inlay and the progression of that amount over time. For this project, neither inlay showed any noticeable debonding until the third year. At the time of the third annual survey, the whitetopping had approximately one percent of its area debonded, while the bonded inlay had approximately three percent. For the fourth annual survey, the percentages were one percent and five percent for the whitetopping and bonded inlay sections, respectively. Finally, at the time of the fifth and final survey, the debonding percentages had risen to five percent and 10 percent for the whitetopping and bonded inlay sections, respectively.

This project has shown one very peculiar distress during the evaluation period. The panels of the driving and passing lane which are considered ultrathin whitetopping are shifting and “growing” uphill towards the intersection. The panels adjacent to the curb which are considered a bonded inlay are not shifting. The current belief is that as traffic approaches the intersection and slows to a stop, they are shoving the whitetopping through the intersection. As can be seen in Figure 1 below, the amount of accumulated movement of the whitetopping compared to the bonded inlay was nearly four inches at the close of the evaluation period. This type and amount of movement would suggest that the entire inlay is debonded and moving; however, the sounding test indicates otherwise. It is believed that the failure plane may be within the underlying HMA layer. If so, the HMA may be shearing without any debonding from the whitetopping inlay. Further evaluation of this phenomenon is recommended when the intersection is eventually removed and rehabilitated.

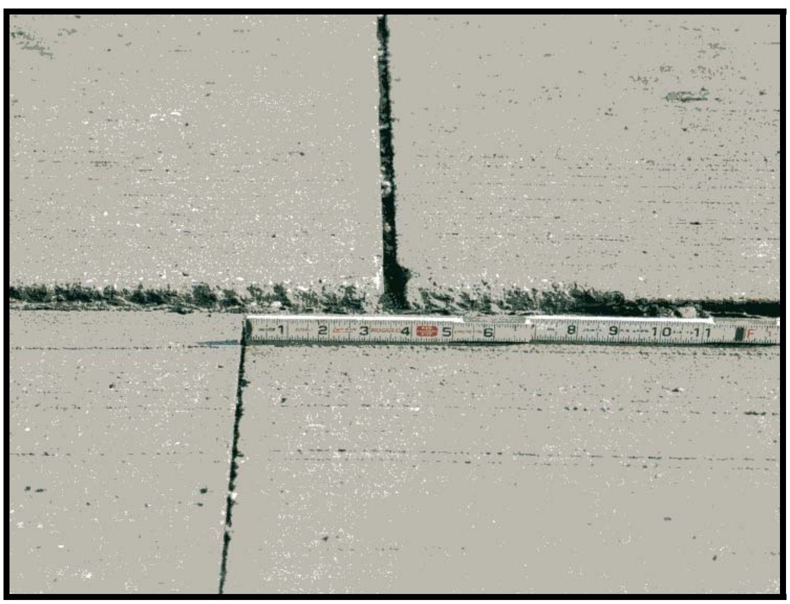

Figure 1

Whitetopping Panel Shifting

DECATUR – INTERSECTION OF U.S. HIGHWAY 36 AND COUNTRY CLUB ROAD

The intersection of U.S. Highway 36 and Country Club Road is located on the east side of Decatur. This project was constructed immediately after the project at the intersection of U.S. Highway 36 and Oakland Avenue. Rehabilitation at this site included the eastbound and westbound driving and passing lanes for U.S. Highway 36 only. This entire project is considered to be a bonded concrete inlay.

U.S. Highway 36 is a divided highway at this intersection which resulted in slightly different cross sections for the eastbound and westbound directions. The existing pavement structure consisted of a 10-inch concrete pavement with a 3.5-inch HMA overlay in the eastbound direction and a 2.5-inch HMA overlay in the westbound direction. Severe rutting and multiple transverse reflective cracks were present in the existing pavement prior to this project. The HMA was completely removed in both directions.

Relief joints were cut into the overlays at underlying cracks and patch boundaries with the remaining joints equally spaced in between. This resulted in an average panel dimension of 2.9 feet by 3.8 feet in the westbound direction and 3.8 feet by 4.5 feet in the eastbound direction. There were no skewed transverse joints used in this project.

The predominant traffic loading at this intersection is from light vehicle traffic. There is only a small percentage (four to seven percent) of heavy commercial vehicle traffic that passes through this intersection on a daily basis. The values given below in Table 3 indicate the amount of traffic and accumulated ESALs that this project carried during the evaluation. As can be seen in the table below, this project carried slightly more ESALs than the previous project.

The values below in Table 4 indicate the number of panels that have a visible crack or distress. In addition to the high number of distressed panels, there have been several panels which required replacement due to severe distress.

Table 3

Traffic Volumes for U.S. Highway 36 and Country Club Road

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
1999	25,150	650	650	23,850	0.21	0.21
2000	24,850	550	550	23,750	0.18	0.39
2001	24,550	725	725	23,100	0.23	0.62
2002	24,075	750	750	22,575	0.24	0.86
2003	23,600	800	775	22,025	0.25	1.11
2004	23,125	775	775	21,575	0.25	1.36

*Highlighted cells are interpolated data points.

Table 4

U.S. Highway 36 and Country Club Road Survey Results

Year of Survey	**1999**	**2000**	**2001**	**2002**	**2003**
2.5-Inch Inlay With 2.9- By 3.8-Foot (Avg.) Panels, Westbound					
Number of Panels Over Concrete	810	810	810	798	798
Number of Panels Cracked	376	393	461	508	562
Percentage Cracked	**46.4**	**48.5**	**56.9**	**63.6**	**70.4**
3.5-Inch Inlay With 3.8- By 4.5-Foot (Avg.) Panels, Eastbound					
Number of Panels Over Concrete	618	618	618	606	606
Number of Panels Cracked	319	337	403	428	436
Percentage Cracked	**51.6**	**54.5**	**65.2**	**70.6**	**72.0**

As can be seen from the values in the table above, the number of distressed panels after only one year of service was roughly 50 percent for both directions. In addition, the number of distressed panels continued to rise during the evaluation period. The rate of increase in distressed panels is approximately the same for both directions. At the conclusion of the evaluation period, both sections had surface distress in over 70 percent of their panels.

For this project, the westbound inlay has shown more debonding than the eastbound direction. The westbound direction displayed approximately three percent debonding in the first distress survey, while the eastbound direction did not display any. At the conclusion of the annual surveys, the westbound direction displayed approximately 10 percent debonding, while the eastbound direction showed only five percent. The construction of the westbound driving lane took place in a light misting rain which required the inlay to be covered with plastic and delayed the initial set. This delay also delayed the saw cutting of the relief joints for this lane. The poor construction conditions, and additional time allowed for internal stresses to develop before saw cutting, may have resulted in more debonding of this direction.

Two large patches have also been placed on this project due to isolated and unrelated failures. The first patch was placed in August of 2001, just three years after construction. This patch occurred in the westbound driving and passing lanes at the location of an old traffic indicator loop in the original concrete pavement. The concrete inlay appeared to heave or “tent” at a full-depth relief joint as can be seen in Figure 2. The appearance of the failure gives evidence that this may have been a pavement “blow-up” due to hot summer temperatures and increased thermal expansion of the concrete inlay.

Figure 2

Bonded Concrete Inlay “Blow-Up” Failure

The concrete inlay was removed with a backhoe and a HMA patch was placed by IDOT maintenance forces. The completed patch may be seen in Figure 3. This HMA patch was still performing very well at the end of the evaluation period.

Figure 3
Hot Mix Asphalt Patch

The second patch was placed in the eastbound driving lane just prior to the traffic signal. This patch was placed in October of 2001 and consisted of a full-depth removal and replacement. The concrete inlay at this location experienced high severity distress and debonding soon after construction. By the fall of 2001, this area was becoming a hazard to the traveling public and required replacement as can be seen in Figure 4.

The cause of this failure is believed to be construction related. The eastbound driving lane was placed the day after a rain event which left standing water on the pavement and in the full-depth patches as shown in Figure 5. The area of this patch is immediately following a full-depth patch placed during construction. Construction photos and documentation indicate that the rain water was not pumped from the patch locations, but rather forced out by the plastic concrete. This excess water on the existing pavement reduced the bonding capabilities of the concrete inlay, and was worked into the plastic concrete reducing the strength of the concrete inlay.

Figure 4

Distressed Bonded Concrete Inlay Prior To Patch

Figure 5

Water Standing In Full-Depth Patches During Construction

The broken and debonded concrete inlay was removed along with the deteriorated existing pavement using a rock chipper attachment on a backhoe. Areas of the concrete inlay within the patch boundary that were not debonded required significant effort by the chipper to break the bond and remove the inlay. This patch was replaced with full-depth concrete as shown in Figure 6.

Figure 6
Full-Depth Concrete Patch Placement

This project has also displayed a significant number of additional distresses that should be noted. The most prominent of these is the occurrence of high severity cracks in the concrete inlay at the location of an existing traffic indicator loop which was left in place. An example of this may be found in Figure 7. Secondly, the majority of the cracking distress noted was transverse mid-panel cracks versus the more traditional corner break cracks associated with whitetopping. Finally, those distressed panels which were not merely mid-panel cracked were cracked in several random directions. The majority of the panels with this type of distress occurred at the pavement centerline, which also served as the longitudinal construction cold joint.

Figure 7
Distress at Traffic Indicator Loop

CARBONDALE – INTERSECTION OF U.S. HIGHWAY 51 AND PLEASANT HILL ROAD

The intersection of U.S. Highway 51 and Pleasant Hill Road is located on the south side of the city of Carbondale. This project was the third one built for the purpose of evaluating whitetopping in Illinois. The rehabilitation at this intersection included the northbound and southbound lanes, including the center turn lane, for U.S. Highway 51 only. Construction was completed in July 1998.

The existing pavement structure consisted of an old two-lane concrete pavement with full-depth HMA widening on both sides. This entire structure was overlaid with HMA to accommodate the two through lanes and center turn lane that were present at the time of construction. The HMA overlay was milled off prior to the rehabilitation, exposing the old two-lane concrete pavement. Therefore, this project was considered to be a combination of ultrathin whitetopping and a bonded concrete inlay like the first project built in Decatur. The center turn lane and one panel row from each through lane were considered a 3.5-inch bonded concrete inlay. The remainder of each through lane was considered a 3.5-inch ultrathin whitetopping as it was built over the full-depth HMA widening.

Relief joints were laid out on a regular pattern of eight to 12 times the thickness of the inlay converted to feet. The resulting average panel dimensions for this project were 3.2 feet by 3.3 feet. There were no skewed transverse joints used on this project.

This project is no longer in service due to a realignment and expansion project for U.S. Highway 51 through Carbondale. The intersection was removed in August 2002 after just four years in service. During those four years of service, however, this project provided the opportunity for excellent side by side comparisons of whitetopping and bonded concrete inlays.

This intersection was situated on the south side of Carbondale and carried a considerable amount of light vehicle traffic from commuters entering and leaving Carbondale for work. There was also a small percentage (four to six percent) of heavy commercial vehicle traffic that passed through the intersection. The values given below in Table 5 indicate the amount of traffic and accumulated ESALs that this project carried. The values in the table below indicate that this project carried a consistent amount of traffic during each of the four years of service and carried nearly 300,000 ESALs before it was taken out of service.

Table 5

Traffic Volumes for U.S. Highway 51 and Pleasant Hill Road

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
1999	13,150	375	125	12,650	0.06	0.06
2000	12,000	425	150	11,425	0.07	0.13
2001	10,850	475	175	10,200	0.08	0.22
2002	11,475	400	150	10,925	0.07	0.29

*Highlighted cells are interpolated data points.

The performance of this project during the four year evaluation was mixed. The values below in Table 6 indicate the number of panels that have a visible crack or distress. There were no panels that required patching or repair during the evaluation.

Table 6

U.S. Highway 51 and Pleasant Hill Road Survey Results

Year of Survey	**1999**	**2000**	**2001**	**2002**
3.5-Inch Inlay With 3.2- By 3.3-Foot (Avg.) Panels				
Number of Panels Over HMA	906	906	906	906
Number of Panels Cracked	4	7	9	13
Percentage Cracked	**0.4**	**0.8**	**1.0**	**1.4**
Number of Panels Over Concrete	906	906	906	906
Number of Panels Cracked	324	380	404	413
Percentage Cracked	**35.8**	**41.9**	**44.6**	**45.6**

The table above indicates that nearly 36 percent of the bonded concrete inlay panels were cracked after only one year of service compared to less than one percent for the whitetopping inlay. In addition, it can be seen that the number of cracked panels continually increased during the evaluation for each type of inlay. At the conclusion of this project's life, more than 45 percent of the bonded concrete inlay panels were cracked compared to only 1.5 percent for the whitetopping inlay.

Debonding of the inlays for this project was noted within six months after construction. The majority of the debonding noted was in the single row of bonded concrete inlay panels of the through lane. Debonding was noted in the panel corners, especially at the intersection of concrete to HMA in the underlying pavement. The percentage of debonding at the first annual survey was approximately one percent and three percent for the whitetopping and bonded inlay sections, respectively. The final distress survey before the project was removed indicated approximately two percent and 10 percent debonding for the whitetopping and bonded concrete inlay sections, respectively.

As stated before, this project was removed from service in August of 2002. Observations were made of the removal process to document the bond of the whitetopping and bonded concrete inlay sections. Removal was completed in sections to accommodate the traffic flow on U.S. Highway 51 during the realignment project. The outline of each section to be removed was first cut with a wheel saw and then removal was done with a backhoe. Both the whitetopping and bonded concrete inlay sections exhibited a good bond to the underlying pavement as pavement removal was difficult with the backhoe. Figures 8 and 9 indicate the bond and the amount of underlying pavement that remained attached to the concrete inlay.

Figure 8

Bond of Whitetopping to Underlying HMA Pavement

Figure 9

Bond of Whitetopping to Underlying Concrete Pavement

As shown in Figure 8 above, the whitetopping inlay of the HMA pavement did not debond, but actually sheared at a depth of 1.5 to 2.0 inches below the HMA to concrete interface. This was typical of the whitetopping sections as they were removed from the pavement structure. Literature from other state agencies and research work indicates a similar occurrence in which the bond of the whitetopping to the underlying HMA is stronger than the internal shear strength of the HMA itself. The actual bond strength of the whitetopping to the underlying HMA is difficult to determine; however, research indicates, as in this case, that milling of the existing surface prior to the whitetopping construction will increase the bond strength.

TUSCOLA – U.S. HIGHWAY 36

The whitetopping construction project on U.S. Highway 36 near Tuscola was the first experimental use of whitetopping as a mainline pavement rehabilitation for this research effort. The project is located in both the eastbound and westbound lanes of U.S. Highway 36 just east of the town of Tuscola and the intersection with Interstate 57. Construction of this project was completed during the summer of 1999.

The existing pavement structure at this location consisted of brick pavers, full-depth concrete pavement, and granular embankment at various locations. The brick pavers and full-depth concrete were overlaid with a 3.0-inch HMA overlay, while the granular embankment was overlaid with a 4.25-inch HMA overlay. This HMA overlay was not milled prior to the construction of the whitetopping. Eighteen partial depth patches were placed at the location of severe transverse reflective cracks prior to construction of the whitetopping. The existing HMA overlay was milled out and new HMA material was placed and compacted in the patch area. This whitetopping consisted of a variable thickness overlay (4.0 to 7.0 inches) for profile and grade corrections.

The longitudinal and transverse relief joints were laid out on a regular pattern for this project. The transverse joints were placed on 5.5-foot centers, and the longitudinal joints were placed at 5.0 and 10.0 feet from the centerline construction joint. The resulting average panel dimensions for the project were 5.5 feet by 5.0 feet. There were no skewed transverse joints used in this project.

This section of U.S. Highway 36 is located in a rural portion of eastern Illinois. The average daily traffic values are not very high compared to the intersection projects; however, the percentage of heavy commercial vehicles is greater at 11 to 16 percent. This may be accounted for by a stone quarry that is located at the mid-point of this project. The values given below in Table 7 indicate the amount of traffic and accumulated ESALs that this project has carried.

Table 7

Traffic Volumes for U.S. Highway 36 (Tuscola)

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
2000	5,500	275	325	4,900	0.11	0.11
2001	4,900	350	450	4,100	0.15	0.26
2002	5,050	350	450	4,250	0.15	0.41
2003	5,200	350	450	4,400	0.15	0.56
2004	5,350	375	475	4,500	0.16	0.72

*Highlighted cells are interpolated data points.

The HMA surface on this project was not milled prior to construction of the whitetopping. This project was expected to debond from the underlying smooth HMA surface. Actually, the result was the opposite. The percentage of debonding was approximately one percent after five years of service. The values below in Table 8 indicate the number of panels that had a visible crack or distress based on the annual surveys of this project.

Table 8

U.S. Highway 36 (Tuscola) Survey Results

Year of Survey	**2000**	**2001**	**2002**	**2003**	**2004**
4.0- To 7.0-Inch Variable Overlay With 5.5- By 5.0-Foot Panels					
Number of Panels Over HMA	4809	4809	4809	4806	4805
Number of Panels Cracked	51	96	155	230	292
Percentage Cracked	**1.1**	**2.0**	**3.2**	**4.8**	**6.1**

As can be seen in the table, only 6.1 percent of the panels had any sign of distress after five years of evaluation. Twenty-four panels required patching and 10 areas required some maintenance activities due to a tenting action of the overlay. The 10 areas that required maintenance have all occurred at a full-depth relief joint of the whitetopping overlay. In the spring of 2003 and 2004, these joints tented up as much as one inch. There are two theories behind the cause of this tenting action.

The first theory is that the underlying full-depth concrete pavement is heaving at a contraction joint during the spring freeze-thaw season and the whitetopping is tenting along with it. However, there is always a void between the whitetopping and the underlying pavement at these tented joints, which contradicts this theory.

The second theory is that the whitetopping overlay is expanding independent of the underlying pavement as the pavement heats up each day. On a given unseasonably hot spring day, the whitetopping expands enough to cause the overlay to tent up. The addition of incompressible material in the relief joints from the winter months increases resistance to expansion and the pressure necessary to cause the tenting action.

Maintenance forces have removed portions of 24 of the tented panels for permanent patches and found a considerable amount of debris build up under the tented panels. The debris suggests that the panels have been grinding against one another as they tent and relax. The remaining panels that have tented have always relaxed and settled back into their normal position after a few days. Maintenance forces have oiled and chipped these areas as a waterproofing measure and to prevent increased problems in the future.

CLAY COUNTY – COUNTY HIGHWAY 3

The Clay County Highway 3 project is situated between the towns of Louisville and Sailor Springs in southeastern Illinois. This project included approximately 8.2 miles of mainline pavement rehabilitation. Construction of this project was completed in the fall of 1998 and included both 5.0-inch and 6.0-inch overlays. The existing pavement structure consisted of a soil cement mixture with an oil and chip surface. The existing pavement surface was scarified prior to placement of the thin whitetopping to reduce variability and defects in the surface.

The majority of this project (7.2 miles) is a 5.0-inch overlay with skewed transverse relief joints on 11.0-foot centers. The remainder of the project (1.0 mile) is a 6.0-inch overlay; however, there are two different relief joint patterns in this area. The first pattern consists of skewed transverse relief joints on 15.0-foot centers. The second pattern consists of skewed transverse relief joints on 5.5-foot centers and an additional longitudinal relief joint at 5.5-feet from the pavement center line. The transverse relief joints were placed on a 1:6 skew.

Clay County Highway 3 is located in a rural portion of Illinois and the roadway receives only a minimal amount of traffic. This area is, however, largely agricultural and this county highway does carry single unit and multiple unit trucks during the fall harvest season. The values given below in Table 9 indicate the amount of traffic and accumulated ESALs that this whitetopping project carried during the evaluation. A large portion of the traffic data for this project has been interpolated based on two known data points for the beginning and end of the evaluation.

Table 9

Traffic Volumes for Clay County Highway 3

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
1999	800	75	25	700	0.01	0.01
2000	800	75	25	700	0.01	0.02
2001	800	75	25	700	0.01	0.03
2002	800	75	25	700	0.01	0.04
2003	800	75	25	700	0.01	0.05
2004	800	75	25	700	0.01	0.06

*Highlighted cells are interpolated data points.

The low amount of ESALs carried by this facility aided in the performance of this project during the five year evaluation. Visual surveys were completed on an annual basis for selected test sections within this project. A 1,000-foot test section was randomly selected for each of the three different overlay scenarios. The results may be found in Table 10.

Table 10

Clay County Highway 3 Survey Results

Year of Survey	**1999**	**2000**	**2001**	**2002**	**2003**
5-Inch Overlay With 11.0- By 11.0-Foot Panels					
Number of Panels Over HMA	182	182	182	182	182
Number of Panels Cracked	0	0	0	0	0
Percentage Cracked	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
6-Inch Overlay With 15.0- By 11.0-Foot Panels					
Number of Panels Over HMA	132	132	132	132	132
Number of Panels Cracked	0	0	0	0	0
Percentage Cracked	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
6-Inch Overlay With 5.5- By 5.5-Foot Panels					
Number of Panels Over HMA	732	732	732	732	732
Number of Panels Cracked	0	0	0	0	0
Percentage Cracked	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

As can be seen in Table 10, there were no cracked or distressed panels within the test sections during the five year evaluation period. Information on panel debonding was not collected as part of the annual distress surveys for this project.

PIATT COUNTY – COUNTY HIGHWAY 4

The thin whitetopping project on Piatt County Highway 4 extends from the eastern city limits of Monticello to the Champaign County line in east-central Illinois. Construction of this project was completed in the fall of 2000 and consists entirely of a 5.0-inch thin whitetopping. The existing pavement structure consisted of a cement aggregate mixture base and 7.0 inches of HMA overlay. Three inches of the existing HMA overlay were milled prior to placement of the concrete overlay.

Four and one-half miles of this five mile project contain transverse relief joints on 11.0-foot centers. The remaining 0.5 mile contains transverse relief joints on 5.5-foot centers and a longitudinal relief joint at 5.5 feet from the pavement center line. The transverse relief joints were placed on a 1:6 skew.

Piatt County Highway 4 is situated within a rural area of Illinois. The area is mostly agricultural which accounts for most of the single unit and multiple unit trucks during the fall harvest season. This road also serves as a “cutoff” for northbound Interstate 57 onto westbound Interstate 72, and vice versa, which accounts for some of the traffic also. The values given below in Table 11 indicate the amount of traffic and accumulated ESALs for this whitetopping project. The traffic data presented in the table below have been interpolated from traffic data records for years previous to 2001. Traffic has not been counted on this facility since 2000; however, the values are typical for rural roadways.

Once again, the low amount of traffic and ESALs carried by this facility has aided in the performance to date. Due to the length of this project, test sections for evaluation were selected from each of the two different scenarios. All of the 5.5-foot by 5.5-foot panels were evaluated along with 100 of the 11.0-foot by 11.0 foot panels. The values in Table 12 indicate the number of cracked or distressed panels recorded during the annual surveys.

Table 11

Traffic Volumes for Piatt County Highway 4

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
2001	2000	75	50	1875	0.02	0.02
2002	2000	75	50	1875	0.02	0.04
2003	2050	100	50	1850	0.02	0.06
2004	2050	100	50	1850	0.02	0.08

*Highlighted cells are interpolated data points.

Table 12

Piatt County Highway 4 Survey Results

Year of Survey	**2001**	**2002**	**2003**	**2004**
5-Inch Overlay With 5.5- By 5.5-Foot Panels				
Number of Panels Over HMA	1912	1912	1912	1912
Number of Panels Cracked	0	2	2	4
Percentage Cracked	**0.0**	**0.1**	**0.1**	**0.2**
5-Inch Overlay With 11.0- By 11.0-Foot Panels				
Number of Panels Over HMA	100	100	100	100
Number of Panels Cracked	0	0	0	1
Percentage Cracked	**0.0**	**0.0**	**0.0**	**1.0**

In the spring of 2003, a school driveway entrance was constructed adjacent to the whitetopping at the west end of the project. Two of the four cracked panels recorded in the 2004 survey are a result of this construction. The one cracked panel recorded for the 11.0-foot panels is the very first panel following the 5.5-foot panels. This panel has a mid-panel sympathy crack from the longitudinal relief joint of the 5.5-foot panels. Information on panel debonding was not collected as part of the annual surveys for this project.

CUMBERLAND COUNTY – COUNTY HIGHWAY 2

The Cumberland County Highway 2 project is located between the towns of Bradbury and Janesville in southeastern Illinois. This 5.75-inch thin whitetopping was constructed in the fall of 2001. The existing pavement structure for this project consisted of a 10.0-inch aggregate base with 6.5 inches of HMA overlay. The existing surface displayed a significant amount of wheel path rutting and some thermal cracking. Three inches of the HMA surface were milled off prior to placement of the thin whitetopping overlay.

This entire project was constructed with transverse relief joints at 5.5-foot spacing. In addition, a longitudinal relief joint was placed 6.0 feet from the pavement centerline. The transverse relief joints were placed on a 1:6 skew.

Cumberland County Highway 2 is located in a rural setting of Illinois. Once again, this area is mostly agricultural which accounts for some of the single unit and multiple unit trucks. The remaining heavy commercial traffic is accounted for by a local aggregate quarry and the use of this facility in place of a railroad spur that has closed. The values given below in Table 13 indicate the amount of traffic and accumulated ESALs that this project has carried to date.

Table 13

Traffic Volumes for Cumberland County Highway 2

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
2002	2,050	325	175	1,550	0.07	0.07
2003	2,050	325	175	1,550	0.07	0.14
2004	2,150	350	200	1,600	0.08	0.22

*Highlighted cells are interpolated data points.

This project is very new, and in combination with the moderate traffic loads, has experienced very little distress to date. Three test sections were selected for monitoring purposes of this project. One test section was located at both the north and south ends of the project, and the third was located in the middle of the project at the intersection of a crossroad. These locations were selected to evaluate performance of the whitetopping as traffic traveled onto and off of the overlay, as well as under turning movements at the crossroad intersection. The values in Table 14 below indicate the number of cracked or distressed panels recorded during the annual surveys.

Table 14

Cumberland County Highway 2 Survey Results

Year of Survey	2002	2003	2004
5.75-Inch Overlay With 5.5-Foot by 6.0-Foot Panels			
Number of Panels Over HMA	1440	1440	1440
Number of Panels Cracked	4	4	4
Percentage Cracked	**0.3**	**0.3**	**0.3**

All four of the distressed panels are located at the north end of the project, and have no relation to traffic traveling onto or off of the whitetopping. The crack that exists in both situations extends from the centerline to the edge of pavement through two panels perpendicular to the direction of traffic. The cracks appear to be indicative of a reflective crack from the underlying pavement structure. Panel debonding information was not collected as part of the annual distress surveys for the three test sections in this project.

ADDITIONAL PROJECTS

Physical Research Report Number 144 [1] documented the construction and early performance for all of the projects discussed above. Two additional projects were constructed with unique features that should be mentioned in this final report. The first project was constructed in 2000 in the city of Harrisburg at the intersection of U.S. Highway 45 and Illinois Route 13. The second project was constructed in 2001 in the city of Anna along Illinois Route 146 at the intersection of Vienna and Main Streets. A brief summary of the construction activities along with the project performance results have been included below.

HARRISBURG – U.S. HIGHWAY 45 AND ILLINOIS ROUTE 13

The first additional research project was constructed in May and June of 2000 at the intersection of U.S. Highway 45 and Illinois Route 13 in Harrisburg. Rehabilitation was completed on the driving lanes and center turn lane for the Illinois Route 13 legs of the intersection. The passing lanes and center turn lane were completed for the U.S. Highway 45 legs of the intersection. This project included a combination of ultrathin whitetopping and bonded concrete inlays. Both legs of U.S. Highway 45, as well as the west leg of Illinois Route 13, were an ultrathin whitetopping inlay. The east leg of Illinois Route 13 was constructed as a bonded concrete inlay.

Transverse cracking, rutting, and shoving of the HMA overlay, were evident in all four legs of the intersection prior to this rehabilitation. Evidence of the rutting may be seen in Figure 10 below. The original pavement cross section consisted of a portland cement concrete pavement overlaid with a nominal 4.5 inches of HMA. This overlay was not present for the driving lanes of U.S. Highway 45 or the eastbound right turn lane on Illinois Route 13. These lanes were added to widen the intersection and consisted of full-depth concrete pavement. The complete layout of the Harrisburg project may be found in Figure 11.

Figure 10

Existing Pavement Rutting

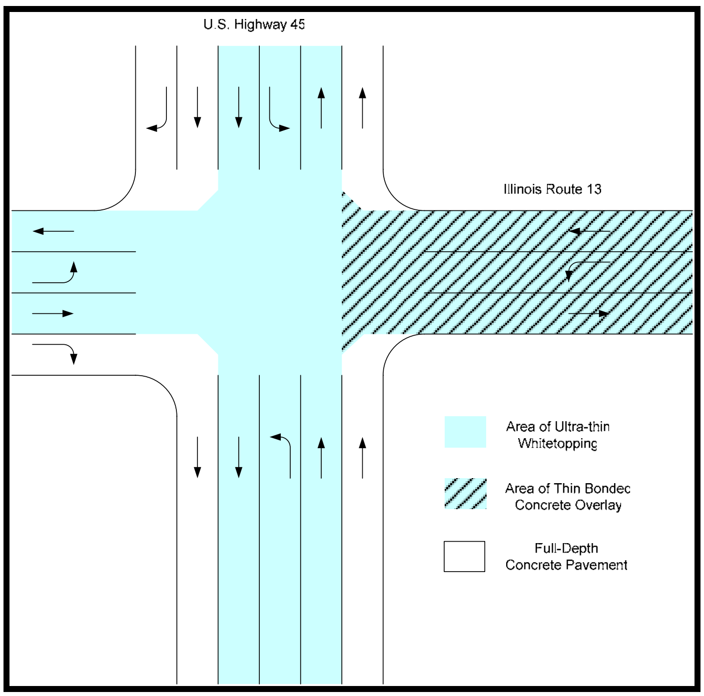

Figure 11

Harrisburg Project Layout

Traffic was detoured away from this intersection for a period of six days to allow for all construction activities. Construction began with the milling of 3.0 inches of the old HMA inlay within the highlighted areas of Figure 11. Following the milling operation, the pavement was cleaned with high pressure water and compressed air. Two by four lumber was used to form the construction joints and control the grade of the 3.0-inch inlay as it was placed.

A light mist was applied to the existing pavement prior to placement of the concrete inlay. The concrete was placed by hand and finished with a double vibratory screed, straightedges, floating, and hand finishing. A coarse broom was used to texture the surface and a white pigmented curing compound was applied shortly after the finishing process. The concrete inlay was constructed in three stages to complete the intersection.

The concrete mixture design for this project was very similar to those used in the previous projects. This mix design included the use of polypropylene fibers added at the rate of 3.0 pounds per cubic yard of concrete.

Relief joints were laid out on a regular pattern of 3.0 feet by 3.0 feet throughout the intersection; however, some joints were shifted slightly in order to place them directly over an underlying transverse crack in the original pavement. Early entry saws were used to cut the partial depth relief joints as shown in Figure 12 below. Full-depth relief joints were placed over most transverse cracks and all construction joints in the underlying pavement. Full-depth relief joints were filled with a hot-poured joint sealant.

Figure 12

Partial-Depth Relief Joint Saw Cutting

Harrisburg is a rural town in southern Illinois; however, the average daily traffic at this intersection is surprisingly high. This intersection is the main crossroads in town with the majority of the traffic on U.S. Highway 45. The values given below in Table 15 indicate the amount of traffic and accumulated ESALs that this project has carried for each of the two routes. The average percentage of heavy commercial vehicles is eight and nine percent for U.S. Highway 45 and Illinois Route 13, respectively.

Table 15

Traffic Volumes for U.S. Highway 45 and Illinois Route 13

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
U.S. Highway 45						
2001	17,050	775	375	15,900	0.14	0.14
2002	16,925	925	425	15,575	0.17	0.31
2003	16,800	1050	500	15,250	0.19	0.50
2004	16,675	900	425	15,350	0.16	0.66
Illinois Route 13						
2001	9,500	575	400	8,525	0.15	0.15
2002	9,300	500	350	8,450	0.13	0.28
2003	9,100	425	300	8,375	0.12	0.40
2004	8,900	475	325	8,100	0.13	0.53

*Highlighted cells are interpolated data points.

This project was included in the evaluation because it is a combination of whitetopping and bonded concrete inlays. The performance of this project has been mixed in the same fashion as the other projects which have combined whitetopping with a bonded concrete inlay. The values below in Table 16 indicate the number of panels that have a visible crack or distress for each type of inlay. There are no panels which have required patching or repair to date.

Table 16

U.S. Highway 45 and Illinois Route 13 Survey Results

Year of Survey	**2001**	**2002**	**2003**	**2004**
3.0-Inch Inlay With 3.0-Foot by 3.0-Foot Panels				
Number of Panels Over HMA	3076	3076	3076	3076
Number of Panels Cracked	25	60	82	90
Percentage Cracked	**0.8**	**2.0**	**2.7**	**2.9**
Number of Panels Over Concrete	1106	1106	1106	1106
Number of Panels Cracked	66	94	98	106
Percentage Cracked	**6.0**	**8.5**	**8.9**	**9.6**

The table above indicates that after only one year of service the bonded concrete inlay experienced six percent cracked panels while the whitetopping was less than one percent. At the time of the last survey, nearly 10 percent of the bonded concrete inlay panels were cracked while only three percent were cracked in the whitetopping section. The amount of debonding was recorded during the annual surveys for this project. The first annual survey in 2001 indicated one percent debonding for the whitetopping and two percent for the bonded concrete inlay. The 2004 survey indicated the same one percent debonding for the whitetopping, but an increase to 11 percent debonding for the bonded concrete inlay.

This project has two areas of medium to high severity distress located at the center of the intersection. One area is located within the whitetopping inlay section and may be seen in Figure 13. This distress also happens to be centered around a construction joint between two stages. The second area of distress is located in the bonded concrete inlay section and may be seen in Figure 14. This distress is located in the westbound lane at the stop line for the intersection. Neither area of distress can be explained by an underlying distress in the original pavement prior to the inlay construction.

Figure 13

Harrisburg Whitetopping Area of Distress

Figure 14

Bonded Concrete Area of Distress

ANNA – ILLINOIS ROUTE 146

The second additional research project was constructed in June of 2001 at the intersection of Vienna and Main Streets along Illinois Route 146 in Anna. This rehabilitation included all of the trafficked lanes within the intersection. This project is unique, in that it is a combination of ultrathin whitetopping and a bonded concrete to brick inlay. The areas of exposed brick were not very well defined; however, their approximate locations may be seen in Figure 15 along with the project layout.

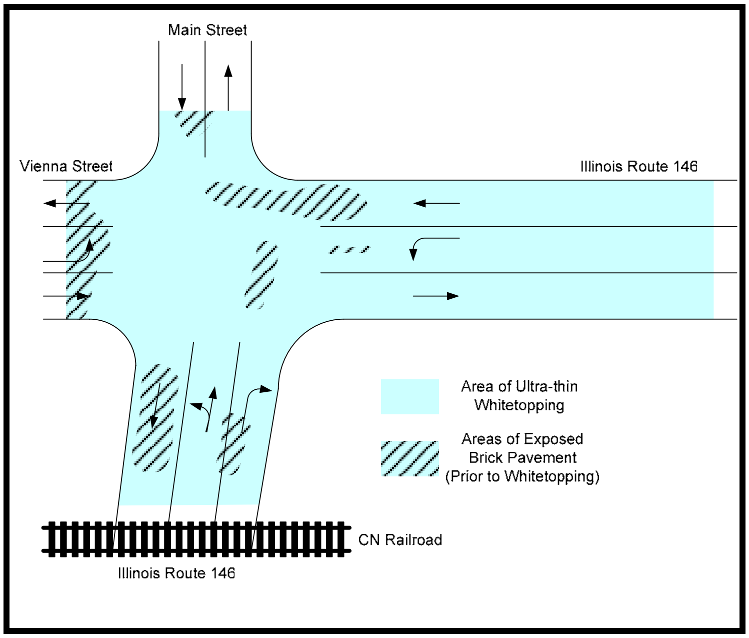

Figure 15

Anna Project Layout

Rutting and shoving of the HMA overlay were the major distresses noted at this intersection prior to the rehabilitation. The rutting was particularly bad in the area of the stop line as may be seen in Figure 16. The existing pavement at this intersection consisted of brick pavers with a variable thickness HMA overlay.

Figure 16

Rutting at the Stop Line

As with the Harrisburg project, traffic was detoured around this intersection for one week to allow for the rehabilitation of the intersection. The existing HMA overlay was milled to a depth of 3.0 inches throughout the entire intersection. This milling operation was accidentally deeper in some areas and shallower in others. The milling operation exposed some of the brick pavers as noted in Figure 15. The milled surface was cleaned with high pressure water and compressed air. This cleaning process also exposed some of the brick pavers and expanded the areas exposed with the milling machine.

Two by four lumber was used to form the construction joints and control the grade of the 3.0-inch inlay as it was placed. The concrete was placed by hand and finished with a single vibratory screed, straightedges, floating, and some hand finishing as shown in Figure 17. The surface was textured with a coarse broom prior to the application of a white curing compound. The concrete inlay was constructed in three stages.

Figure 17
Anna Concrete Placement

Relief joints for this project were laid out in the same fashion as the Harrisburg project. Longitudinal and transverse relief joints were laid out on a 3.0-foot by 3.0-foot pattern with some joints shifting slightly to accommodate manholes and the geometrics of the intersection. Early entry saws were used to cut the partial depth relief joints. Full-depth relief joints were placed at all construction joints and some of the transverse cracks in the underlying pavement. Full-depth relief joints were filled with a hot-poured joint sealant.

Anna is also a small rural town in southern Illinois; however, the average daily traffic and, more importantly, the quantity of heavy commercial vehicles are quite high. Illinois Route 146 is used by many motorists and heavy commercial vehicles as a cutoff between Interstate 57 and Cape Girardeau, Missouri. Illinois Route 146 is the only route crossing the Mississippi River for nearly 100 miles between Cairo and Chester, Illinois. The values given below in Table 17 indicate the amount of traffic and accumulated ESALs that this project has carried to date. The average percentage of heavy commercial vehicles has ranged from eight to nine percent during the three years evaluated.

Table 17

Traffic Volumes for Illinois Route 146

Year	ADT	Single Unit Trucks	Multiple Unit Trucks	Passenger Vehicles	Year's ESALs (x 10^6)	Cumulative ESALs (x 10^6)
2002	14,700	700	450	13,550	0.18	0.18
2003	13,800	775	500	12,525	0.20	0.38
2004	13,500	625	425	12,450	0.16	0.54

*Highlighted cells are interpolated data points.

In addition to the traffic values listed above, it should also be noted that at this intersection Illinois Route 146 makes a 90 degree turn. Therefore, this intersection has provided an excellent example of how whitetopping can mitigate rutting at the stop line, and also shoving throughout the intersection as heavy commercial vehicles perform a turning action. The values below in Table 18 indicate the number of panels that have a visible crack or distress. No panels have required any patching or maintenance to date.

Table 18

Illinois Route 146 Survey Results

Year of Survey	**2002**	**2003**	**2004**
3.0-Inch Inlay With 3.0-Foot by 3.0-Foot Panels			
Number of Panels Over HMA	1706	1706	1706
Number of Panels Cracked	201	272	340
Percentage Cracked	**11.8**	**15.9**	**19.9**

As can be seen in the table above, the project has seen a steady rise in the number of distressed panels from nearly 12 percent after one year to nearly 20 percent after three years. More than half of the distressed panels appear to be in areas where the concrete inlay was bonded directly to the underlying brick pavers. The debonding rate for this intersection has consistently been five percent for each of the three years surveyed.

There is one area of high severity distress in the eastbound driving lane as seen in Figure 18. The area appears to be a slight depression; however, there is no noticeable deflection under the loaded axle of a tractor trailer. In addition, there is no evidence of an underlying defect in the original pavement at this area.

Figure 18

Anna Whitetopping Area of Distress

SUMMARY

The Illinois Department of Transportation constructed nine whitetopping projects between 1998 and 2004 and evaluated them for construction difficulties and performance. These whitetopping projects were constructed as ultrathin whitetopping, thin whitetopping, and bonded concrete inlays and overlays. Rehabilitations included intersections and mainline pavements on U.S. Highways, Illinois State Routes, and County Highways.

Five intersection projects were constructed to evaluate the ability of the whitetopping to mitigate rutting, shoving, and cracking distresses that are common at intersections constructed with HMA. These projects were constructed at: U.S. Highway 36 and Oakland Avenue in Decatur, U.S. Highway 36 and Country Club Road in Decatur, U.S. Highway 51 and Pleasant Hill Road in Carbondale, U.S. Highway 45 and Illinois Route 13 in Harrisburg, and Vienna and Main Streets along Illinois Route 146 in Anna. Four of these five projects are considered to be a combination of whitetopping and bonded concrete inlays. The exception is the intersection of U.S. Highway 36 and Country Club Road, which is entirely a bonded concrete inlay.

Four projects were constructed to evaluate the ability of the whitetopping to improve the ride quality and provide a long-term rehabilitation for mainline pavements with aged HMA surfaces. These projects were constructed at: U.S. Highway 36 east of Tuscola, Clay County Highway 3 near Louisville, Piatt County Highway 4 near Monticello, and Cumberland County Highway 2 near Bradbury. All four of these projects are considered to be thin whitetopping.

Construction procedures and details including construction costs for the first seven projects were documented in Physical Research Report No. 144 [1]. Construction details for the remaining two projects (Harrisburg and Anna) are included in this report. Accumulated traffic volumes and ESALs for each project were collected and included with this report.

The average amount of accumulated ESALs for these projects has varied slightly between the county and state routes. The county highway projects have ranged from 10,000 to

80,000 ESALs per year on various projects. The state highway projects have ranged from 60,000 to 250,000 ESALs per year on various projects. The variations in the annual amount of accumulated ESALs provide a good basis to relate performance with annual traffic volumes. The three county highway projects all have excellent performance which is due in part to the low amount of accumulated ESAL loadings. The state highway projects have mixed results, with more distress apparent on those projects which carry increased annual ESAL loadings.

As a means of evaluating the performance of these projects, an annual visual distress survey was performed on the entire project for intersections and on select test sections for the mainline pavement projects. Included with the visual distress surveys of the intersection projects was a sounding test for the percentage of debonded panels.

Performance was also evaluated with regards to the type of whitetopping that was constructed. In general, the thin whitetopping projects that were constructed as part of this research effort have performed very well. Also, the ultrathin whitetopping projects that were constructed with at least 3.0 inches of remaining HMA beneath them have performed very well. The bonded concrete inlay portions of the intersection projects that were constructed, in general, have not performed as well as the whitetopping inlays.

CONCLUSIONS

Nine experimental ultrathin and thin whitetopping projects were constructed and evaluated in Illinois as part of this research effort. Five of these projects included the rehabilitation of an intersection, while the remaining four were mainline pavement rehabilitations. The following conclusions were made after monitoring the construction and performance of these whitetopping projects. These conclusions have been drawn from Physical Research Report No. 144 as well as the content of this Physical Research Report.

The construction staging and traffic control operations are critical items to the success of the project. The complete closure of the project to traffic is the best alternative; however, in situations where that is not possible the construction should be staged to control traffic flow. Mobil traffic signals and single lane construction can be used successfully.

Preparation of the existing pavement surface is necessary for improved performance. Milling or scarifying of the pavement surface will eliminate contaminants and remove irregularities in the pavement surface. The milling or scarification also provides more surface area for bonding of the whitetopping to the underlying pavement. The milling or scarification should be followed by a thorough cleaning of the pavement surface prior to concrete placement. Ultrathin overlays should utilize a mechanical broom and cleaning with high pressure water. Thin overlays should utilize the mechanical broom.

Areas of high severity distress in the underlying pavement should be patched prior to the whitetopping rehabilitation. A hot mix asphalt patch material is recommended, and the patch surface should be scarified prior to placement of the whitetopping.

Concrete placement may be done by hand or slip-form paving machine. Care should be taken to avoid concrete placement during extreme heat or high winds to avoid rapid curing of the ultrathin overlays. Normal concrete placement and finishing techniques should be used for placement of both ultrathin and thin whitetoppings. The application of curing compound should be done as soon as possible after concrete finishing to avoid rapid curing.

Partial-depth relief joints should be cut as soon as the concrete will support the weight of the equipment and the operator. Care should be taken to avoid spalling of the cuts from premature sawing. Full-depth relief joints should be placed over items in the underlying pavement where expansion and contraction is expected. These items may include cracks, construction joints, contraction joints, or patch boundaries. The full-depth joints should be sealed with a hot-poured joint sealant.

The cost comparison between whitetopping and HMA overlays was limited to the initial construction cost. The comparison for small quantity intersection rehabilitations indicates that the ultrathin whitetopping has an increased initial cost compared to an HMA overlay. The comparison for large quantity mainline pavement rehabilitations indicates that the thin whitetopping and HMA overlay are comparable based on initial cost. A life cycle cost comparison will ultimately determine the more economical product.

The performance of the ultrathin whitetopping sections has been very good. The whitetopping was successful at mitigating the rutting and shoving present at several of the rehabilitated intersections. The amount of HMA present under the ultrathin whitetopping appears to be critical to the performance. As the amount of remaining HMA decreased, the amount of surface distress increased for the experimental projects. The projects that included a concrete overlay placed directly on underlying concrete or brick pavers have not performed as well as the ultrathin whitetopping. The cutoff amount of remaining HMA for acceptable performance of the ultrathin whitetopping appears to be 3.0 inches.

The performance of the thin whitetopping projects has been excellent. The whitetopping was successful at mitigating surface rutting and providing a surface with an improved ride quality. There has been little to no distress identified with the thin whitetopping overlays.

A special provision for use in contract documents and design guidelines for pavement designers were developed as a result of the favorable performance of the ultrathin and thin whitetopping projects. The special provision outlines the minor differences used for construction of a whitetopping overlay when compared to standard construction of concrete pavement. The design guidelines provide guidance and outline items for consideration when designing a whitetopping. The design guidelines also contain charts for selecting the whitetopping thickness and relief joint spacing based on traffic volumes and the amount of remaining HMA on the project. The special provision and design guidelines may be found in Appendices A and B, respectively.

RECOMMENDATIONS

Based on the construction activities, accumulated traffic loadings, and performance results for the nine projects evaluated and information gathered from other Midwestern states, the following recommendations can be made about the construction of whitetopping projects for intersections and mainline pavements.

1. The use of bonded concrete inlays is not recommended for intersection rehabilitation projects. Results from this research investigation indicate an increased amount of distressed panels and debonded panels with the use of bonded concrete inlays.

2. The use of ultrathin whitetopping for intersections and thin whitetopping for the rehabilitation of county highways is recommended. Results from this research investigation indicate excellent performance with these types of rehabilitation. Design guidelines and a special provision for use in contract documents have been developed for selection and construction of these rehabilitations.

3. A sufficient amount of quality HMA material must remain in place beneath a whitetopping inlay or overlay. The design guidelines developed from this research specify three inches of quality HMA to remain in place.

4. Patching of severe transverse cracks, potholes, and other major distress in the existing pavement surface is recommended prior to construction of the whitetopping inlay or overlay. It is also recommended to remove all traffic loop detectors and unused utilities from the existing pavement prior to construction of the whitetopping inlay or overlay.

5. Milling or scarification of the existing HMA surface is recommended. This process removes any contaminants from the HMA surface, removes rutting and other surface distress, provides a level construction platform, and increases the surface area for bonding of the whitetopping inlay or overlay.

6. It is recommended to utilize early entry techniques for saw cutting of the relief joints. Early entry relief joint cutting relieves curling and warping stresses that build up quickly in thin inlays and overlays. Caution is advised to avoid premature cutting which may lead to spalling of the relief joints.

7. A final visual distress survey along with a report on the lifespan and reason for rehabilitation is recommended for these projects in the future. This data may be used to compare whitetopping with other types of similar rehabilitation, calculate the life cycle costs, and calculate the total ESAL values for each whitetopping project. The resulting data may then be used to make further recommendations on the use of whitetopping.

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APPENDIX

A

WHITETOPPING SPECIAL PROVISION

PORTLAND CEMENT CONCRETE INLAY OR OVERLAY (BMPR)

Effective: January 1, 2005

Description. This work shall consist of constructing a portland cement concrete inlay or overlay. Work shall be according to Section 420 of the Standard Specifications except as modified herein. Articles 420.05, 420.10, 420.14, 420.19, and 420.20 shall not apply.

Materials. Materials shall be according to the following.

Item	Article/Section
(a) Portland Cement Concrete (Note 1)	1020
(b) Synthetic Fibers (Note 2)	
(c) Protective Coat	1023.01

Note 1. Class PV concrete shall be used except the cement factor for central mixed concrete shall be 360 kg/cu m (6.05 cwt/cu yd).

The cement factor for Class PV concrete shall not be reduced if a water-reducing or high range water-reducing admixture is used.

The Class PV concrete shall have a compressive strength of 20,700 kPa (3,000 psi) or flexural strength of 3,800 kPa (550 psi) at 14 days.

Note 2. Synthetic fibers shall be Type III according to ASTM C 1116. The synthetic fiber shall be a monofilament with a minimum length of 13 mm (0.5 in.) and a maximum length of 50 mm (2.0 in.), and shall have an aspect ratio (length divided by the equivalent diameter of the fiber) between 80 and 100. The synthetic fiber shall have a minimum modulus of elasticity of 9,000,000 kPa (1305 ksi) and a minimum tensile strength of 500,000 kPa (72.5 ksi).

The synthetic fibers shall be added to the concrete and mixed per the manufacturer's recommendation. The dosage rate shall be 2.4 kg/cu m (4.0 lb/cu yd).

The Department will maintain an "Approved List of Synthetic Fibers".

Equipment. Equipment shall meet the requirements of Article 420.03 except, the mechanical saw used for cutting relief joints shall be equipped with an upcutting blade and a restricting skid plate to prevent spalling of the finished saw cut.

CONSTRUCTION REQUIREMENTS

Preparation of Existing Pavement. The area to be overlaid shall be milled as shown on the plans. When patching is required, the patches shall be milled or their surface given a rough texture.

Following milling, the surface shall be cleaned as follows.

(a) Plan Thickness less than 125 mm (5 in.). For these inlays or overlays, the surface shall be cleaned with high-pressure water. A 13,800 kPa (2,000 psi) minimum operating pressure shall be maintained for the high-pressure water spray.

(b) Plan Thickness of 125 mm (5 in.) or greater. For these inlays or overlays, the surface shall be cleaned with a mechanical broom, compressed air, or water.

The prepared surface shall meet the approval of the Engineer prior to proceeding with the work.

<u>Forms and Form Setting</u>. This work shall be according to Article 420.06 except wood forms of a height equal to the proposed inlay or overlay thickness may be used. Shims or wedges may be used to raise the forms to the specified plan elevation.

<u>Treatment of Structures in the Pavement</u>. Pavement round-outs shall be used at structures in the pavement. This work shall be as shown on the plans.

<u>Placing</u>. This work shall be according to Article 420.07 except standing water on the existing pavement surface shall be removed prior to concrete placement.

<u>Relief Joints</u>. Joints shall be constructed at the locations and spacings shown on the plans. Field adjustments to the transverse joint locations will be permitted provided no transverse joint exceeds the planned spacing by more than ten percent.

The joints shall be mechanically sawed or hand tooled to 1/4 the depth of the inlay or overlay, and shall be a minimum 3 mm (1/8 in.) and a maximum 6 mm (1/4 in.) wide. Sawed joints shall be constructed as soon as the concrete will support the weight of the saw and operator without disturbing the final finish. Hand tooled joints shall be edged with an edging tool having a 3 mm (1/8 in.) radius. Care shall be taken to minimize displacement of the finished surface.

<u>Final Strike Off, Consolidation, and Finishing</u>. This work shall be according to Article 420.11 except, when a Type B final finish is specified, it shall be followed by a rough broom finish struck perpendicular to the direction of traffic flow. The rough broom finish shall be performed over the entire surface including tooled joints.

<u>Opening to Traffic</u>. This work shall be performed according to Article 420.16 except, curing may be discontinued and the pavement opened to traffic when a flexural strength of 3,800 kPa (550 psi) or a compressive strength of 20,700 kPa (3,000 psi) is attained.

<u>Basis of Payment</u>. This work will be paid for at the contract unit price per square meter (square yard) for PORTLAND CEMENT CONCRETE INLAY or PORTLAND CEMENT CONCRETE OVERLAY, of the thickness specified.

APPENDIX

B

WHITETOPPING DESIGN GUIDELINES

SUBJECT: Guidelines for Portland Cement Concrete Inlay or Overlay

DATE: January 1, 2005

Applicability

These guidelines are to be followed to: (a) review the existing pavement structure, (b) identify design considerations, and (c) prepare a request for review and approval of a portland cement concrete (PCC) inlay / overlay system. This alternative rehabilitation strategy shall apply only to Class II, III, and IV pavements.

Background

The stopping, starting, standing, and turning actions of vehicles at intersections can be very rigorous on pavement structures with hot mix asphalt (HMA) surfaces. The resulting pavement will rut and allow standing water to create a hydroplaning hazard during rain events. In addition, the ruts collect snow and ice and create potential hazards to snowplows during snow events. These scenarios are very hazardous to the traveling public. The use of a portland cement concrete (PCC) inlay / overlay at these intersections may reduce the pavement distress and reduce the hazards to the motorist.

A PCC inlay / overlay consists of placing a thin, synthetic fiber reinforced, concrete on an existing HMA pavement structure. Placement at urbanized intersections generally includes milling some of the existing rutted HMA to create an inlay versus overlay situation. Placement on rural roadways may include milling to correct profile irregularities and provide a scarified surface for bonding of the overlay. A PCC inlay / overlay should be considered as an alternative at intersections where HMA overlays frequently rut and have short performance lives. A PCC inlay / overlay may also be considered on rural roadways where rutting and profile corrections are a concern and an extended performance life is desired.

The benefits of a PCC inlay / overlay are: elimination of the pavement rutting, reduced standing water and hydroplaning, increased visibility, increased skid resistance, and a longer performance life compared to a hot mix asphalt overlay.

These guidelines may be used in the evaluation of an existing intersection or pavement to determine if the use of a PCC inlay / overlay is feasible and constructible. These guidelines also contain the design steps needed to successfully complete this option. The use of a PCC inlay / overlay should follow a thorough review of the existing pavement structure, as well as close attention to utility, profile, and elevation adjustments. This technique requires a bonding action to the underlying pavement and multiple relief joints at an early age to control cracking and curling stresses within the inlay / overlay.

Limitations

The performance of PCC overlay sections can be variable. Many times, the pavement cross section contains an old slab of concrete or brick pavement. The designer is strongly cautioned to maintain a reasonably sound bituminous overlay of 3.0 inches or more over these types of slabs. Past projects which required the placement of the concrete overlay directly on an existing concrete or brick pavement have resulted in a high degree of surface distress.

Concrete inlays and overlays less than 5.0 inches should be viewed as a rehabilitation, and a reasonable performance life of 15 years can be expected. An inlay or overlay thickness of 5.0 inches or more is likely to provide good service over a longer period. The designer shall use a design period of 20 years in this case due to the small thickness increase to provide increased service life.

Procedures

The selection of a PCC inlay / overlay should be the result of a thorough review of the existing pavement structure, existing and proposed ADT, design considerations, construction sequencing and feasibility, and an examination of other alternatives.

(a) Review of the Existing Pavement Structure

A thorough investigation of the existing pavement structure should be conducted. The purpose of this investigation is to determine if the section in question is suitable for a PCC inlay / overlay. It is essential that only appropriate sections be selected for this rehabilitation option.

(1) Preliminary Pavement Investigation

Prior to requesting a detailed pavement investigation, the designer should research the past rehabilitation attempts as well as the future plans for the area that surrounds the intersection / roadway. Research of the past rehabilitation attempts will provide information on why the past rehabilitation methods have not performed as desired. Insight into the future plans for the pavement and area surrounding the project may influence the design of the rehabilitation.

The designer should also consider the general constructability of a PCC inlay / overlay at the selected location. The existing HMA pavement that is to remain in place must be a minimum of 3.0 inches thick. If a portion of the PCC inlay / overlay will be bonded directly to bare concrete, this rehabilitation method should not be used. Construction is also hindered by complicated geometrics, utility obstructions, traffic demand, and the condition of the existing pavement.

If it appears that a PCC inlay / overlay can be constructed at the intersection / roadway, then a detailed pavement investigation is necessary to verify the constructability of the inlay / overlay.

(2) Detailed Pavement Investigation

Upon completion of the preliminary investigation, the District may request Falling Weight Deflectometer (FWD) testing from the Bureau of Materials and Physical Research for determination of substructure support ratings. In addition, a detailed pavement coring plan should be developed and administered by the District. In general, cores will be taken to represent all pavement cross sections and all locations within the project. A document with guidelines for material sampling entitled “Guidelines for Material Sampling and Testing of Existing Bituminous Concrete Pavements and

Overlays" is available through the Central Bureau of Materials and Physical Research. The coring plan should be completed to specifically address the following points.

- HMA overlay total thickness and thickness for each layer detected
- Condition and tensile strength of the HMA overlay for each layer detected
- Presence of stripping within the HMA overlay
- Underlying pavement thickness and type
- Compressive strength (if concrete) and tensile strength (if HMA) of the underlying pavement
- Presence of D-cracking (if concrete) or stripping (if HMA) within the underlying pavement
- Identification of locations where patching or alternative rehabilitation methods are recommended.

In addition to the coring plan, a general inspection of the project limits should be completed. In general, the inspection will address items such as geometrics, drainage, utilities, and surface abnormalities. More specifically, the inspection should address the following points.

- Intersection of pavement crowns (Multi-leg intersections)
- Location of drop inlets
- Location of loop detectors for traffic signals
- Location of sewer manholes, water valves, and all other utility obstructions
- Location of existing surface patches
- Location of high severity distress cracks
- Clearances for overheads

(3) Existing and Projected Annual Daily Traffic

An accurate count of the existing Annual Daily Traffic (ADT) with a breakdown of percentages for passenger vehicles, single unit, and multiple unit trucks should be performed. In addition, estimates for the projected ADT and classification breakdown should be developed for the design period.

Upon completion of the coring and inspection procedures, and the collection of traffic data, a report should be created to document this information.

(b) Identify Design Considerations

There are several design issues that must be considered before a PCC inlay / overlay project can be submitted for review and approval. A list of issues that may be resolved prior to the submittal of a design is as follows:

(1) Design Period

The design period to be used for this rehabilitation strategy is 15 years. If the resulting inlay or overlay thickness is 5.0 inches or greater, the designer shall use a 20 year design period.

(2) Cost Alternatives

Consideration should be given to the cost analysis of several different rehabilitation options. Cost analyses include items such as the initial construction cost, annual maintenance costs, and the expected lifespan of the rehabilitation option. Cost alternatives may also be warranted for various options within the same rehabilitation technique.

(3) Drainage Considerations

Maintaining proper drainage through design and during construction is very important. Design of the PCC inlay / overlay must include a crowned section to ensure proper drainage to the edge of the roadway. During construction, maintaining drainage is especially critical for projects that include an inlay.

(4) Pavement Patching

Severely deteriorated areas of the existing pavement that are present before, or after, the milling operation must be repaired. Such areas include large potholes, raveled areas, and severe cracks. Large repairs generally will include additional milling and placement of an HMA patch. The finished surface of any patch placed after the initial milling operation is complete must be milled or the surface given a rough texture. The rough surface produced by the milling operation provides increased bonding surface area for the PCC inlay or overlay.

(5) Thickness Design and Relief Joint Spacing

The PCC inlay / overlay thickness design is based on a unique combination of variables including design traffic, underlying pavement structural support, and the final panel dimensions of the inlay or overlay. The minimum thickness allowed is 2.0 inches, and the maximum thickness should not exceed 6.0 inches. Designs greater than 6.0 inches should consider the addition of reinforcement steel and follow the guidelines of an unbonded concrete overlay or be reconstructed.

The traffic factor should be determined according to the appropriate class of roadway and type of facility. Based on the traffic factor and the known amount of bituminous material that will remain in place under the inlay / overlay, the PCC thickness and relief joint spacing may be determined from the appropriate table below. Interpolation between thickness values in the following tables should always result in the use of the smaller relief joint spacing option.

Table 1
PCC Thickness and Relief Joint Spacing
Remaining Bituminous Material, 3.0 in. ≤ X < 5.0 in.

Traffic Factor	PCC Thickness (in.)	Relief Joint Spacing (in.)
< 0.05	2	24
< 0.1	3	36
< 0.3	4	48
< 0.6	5	72
< 1.7	6	72

Table 2
PCC Thickness and Relief Joint Spacing
Remaining Bituminous Material, X ≥ 5.0 in.

Traffic Factor	PCC Thickness (in.)	Relief Joint Spacing (in.)
< 0.3	2	24
< 0.6	3	36
< 1.0	4	48
< 1.6	5	72
< 4.0	6	72

A key to the success of a PCC inlay / overlay is the longitudinal and transverse relief joints. These joints are hand tooled into the plastic concrete or sawed into the hardened concrete to provide stress relief induced by drying shrinkage and curling of the concrete. These joints should be laid out on a regular pattern for both the longitudinal and transverse directions based on the spacing from the appropriate table above. No skewed joints will be allowed.

Transverse and longitudinal relief joints should be laid out to match joints, utility obstructions, and geometrics of the existing pavement as much as possible. The longitudinal relief joints should be laid out to avoid the wheelpath areas of the traveling lanes. The layout of all transverse and longitudinal relief joints should be detailed on the plan sheets.

There is a direct trade off in cost for saw cutting and inlay / overlay thickness. For example, the cost per square yard of a 2.0 inch concrete overlay with a 24.0 inch panel size may be similar to a 6.0 inch concrete overlay with a 72.0 inch panel size. The thicker inlay or overlay is preferred for long term performance.

(6) Profile Correction

Large profile corrections to the existing pavement should be a part of the initial milling operation. A hot mix asphalt overlay or repair may be needed in some cases to correct a sag vertical curve or insufficient pavement crown. The finished surface of any hot mix asphalt overlays placed after the initial milling operation is complete must be milled or have the surface roughed up

The PCC inlay / overlay may also include a variable thickness for profile correction of the existing pavement surface. If this occurs, the design thickness and relief joint spacing for each portion of the project should be based upon the thinnest section that is anticipated for that portion of the project.

(7) Final Finish

A Type B final finish followed by a rough broom finish struck perpendicular to the direction of traffic flow shall be used at all locations with a posted speed limit of 45 mph or less. The rough broom finish shall be used across the entire surface area of the inlay or overlay including any hand tooled joints.

The "Special Provision for Type A Final Finish of Portland Cement Concrete Pavement with Variably Spaced Tining (BMPR)" shall apply at all other locations.

(8) Traffic Control

The control of traffic through the project must be considered and well established prior to the time of construction. The best alternative for traffic control is to completely close the project to traffic. This alternative may be difficult for urban projects; however, somewhat easier for rural projects. If closure to traffic is not possible, traffic control must be established that will effectively move traffic through the project with minimal disruption to construction operations and traffic flow. Traffic control that can be left unattended overnight must be anticipated for each stage of construction.

(9) Construction Staging

Construction staging for a PCC inlay / overlay project must be considered with respect to the construction timeframe and traffic flow through the project. The project must be staged in such a way that continuous traffic flow will be maintained. Construction staging must also consider the geometrics of the project and any lane to lane drop off restrictions that may be present with the overlay thickness.

The concrete mixture design for these inlays or overlays is designed to reach a predetermined compressive or flexural strength within 14 days. Normally, these mixture designs will acquire the strength requirements in 3 days. The completed inlay or overlay may not be opened to traffic until these strength requirements are met. If the inlay or overlay must be opened to traffic in less than 3 days, consult the District materials office for an acceptable concrete mixture.

(c) Request for Review and Approval

All proposed PCC inlay / overlay projects must be submitted for approval to the Bureau of Design and Environment. At a minimum, this submittal should include the following: 1) a report of the preliminary and detailed pavement inspections, 2) existing and proposed cross sections, 3) existing and projected traffic information, 4) construction sequencing and proposed traffic control, and 5) a summary on why a PCC inlay / overlay is the preferred method of rehabilitation over other alternatives.